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PHARMACOGNOSTIC STUDIES ON THE STEM BARKS OF FOUR SPECIES OF *CINNAMOMUM*

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ABSTRACT

The pharmacognostic studies on the stem barks of four species of *Cinnamomum viz. Cinnamomum zeylanicum* Blume, *C. camphora* Nees & Eberm., *C. tamala* Fr. Nees & *C. iners* Reinw. have been made. Macroscopic and microscopic characters and the characters of the powders of each bark have been studied and the authentic diagnostic characters of each bark were noted down in the table. These will remove confusion in proper identification of the market samples and will also help in checking adulterations.

INTRODUCTION

It is often found in the crude drug trade that the barks of different species of *Cinnamomum* are sold in the market under the commercial name Ceylon Cinnamon. According to I.P.(6) and B.P.(2) Cinnamon bark is the dried inner bark of the shoots of coppiced trees of *Cinnamomum zeylanicum* Blume (Fam. Lauraceae). Some barks which are not definitely *C. zeylanicum* but possess more or less same fragrant odour and mucilaginous taste are sold in the market as Cinnamon bark of commerce under the trade name Dalchini. It is therefore necessary to get the pharmacognostic details of the barks by which the authentic bark samples can be easily and properly identified through their diagnostic characters and particularly when they are found in a mixed-up condition or adulterated with other barks of this type.

The present paper deals with the pharmacognostic studies of the barks of four species of *Cinnamomum i.e. C. zeylanicum* Blume, *C. camphora* Nees & Eberm., *C. tamala* Fr. Nees and *C. iners* Reinw.

Materials & methods: The materials for studies were collected from Indian Botanic Garden, Shibpore, different regions of India and also from different drug dealers. The barks collected from different regions and drug dealers were compared with the authentic samples.

In the macroscopical studies of the barks the internal and external colours, shape, nature of curvature, fracture and the thickness of the barks were noted in each case. Photographs of the barks showing the macroscopical appearances of the inner and outer sides were taken and presented in Plate I. Each bark was powdered and passed through sixty B.S. sieve to study the colour, taste and smell if any.

The microscopical studies were made by cutting sections with the help of a hand microtome in transverse, radial-longitudinal and tangential-longitudinal directions to study the internal structures of the different elements of the barks with their peculiarities. Retouched photomicrographs of the transverse, radial-longitudinal and tangential-longitudinal sections of the barks were represented in the plates. The bark powders were studied microscopically. The different elements of the powdered barks which were considered as diagonostic elements were drawn with a camera lucida and photographs of these elements were included in the plates containing retouched photomicrographs. The nature of starch grains, crystals of calcium oxalate and stone cells were also drawn in details and shown in a different plate.

Cinnamomum zeylanicum Blume Hindi: Dalchini; Sans.: Bahugandha; Beng.: Dalchini, Darchini; Tam.: Karuva, Cannalavangapattai; Tel.: Lavabgamu is a moderate sized evergreen tree distributed in Ceylon, Burma, W. Peninsula and cultivated in South India. The bark is rather thick, smooth, pale twice often compressed (1, 3, 4, 7, 8, 11, 13).

Macroscopic characters: The bark when fresh is 1 to 5 mm sometimes upto 10 mm in thickness. Outer surface yellowish-brown to dark brown and sometimes greenish brown. The outer surface is either smooth or rough, uneven, irregularly fissured and longitudinally striate showing circular or irregualr brownish patches occasionally with perforations, that indicate the positions of the nodes.

The outer layer of the cork region is somewhat easily separable. In the commercial samples the outer surface is devoid of suberous coat and often some parts of middle region. The middle part of the bark is granular due to the groups of stone cells. Inner surface brownish to dark brownish in colour, smooth and soft with faint striae. Fracture weak, brittle, splintery and uneven with projecting fibres. Curvature in closely rolled categories of quills. Odour fragrant and strong (2, 4, 5, 6, 11, 12, 14). (Plate I, Fig. 1.)

Microscopic characters : The phellem or cork consists of 5-10 layers of tangentially elongated, more or less thin-walled, slightly suberized cells. In official as well as commercial samples these layers may be completely absent. The cork cells adjacent to the cortex are thin-walled with inner tangential walls sclerosed (Plate II, Figs. 1 & 2). The cork cells measure $T = 16\mu\text{-}35\mu\text{-}60\mu$, $R = 8\mu\text{-}14\mu\text{-}21\mu$ and $L = 18\mu\text{-}25\mu\text{--}35\mu$. The phellegen and phelloderm layer are not very distinct in this species and the cortex is not sharply defined from the peri-

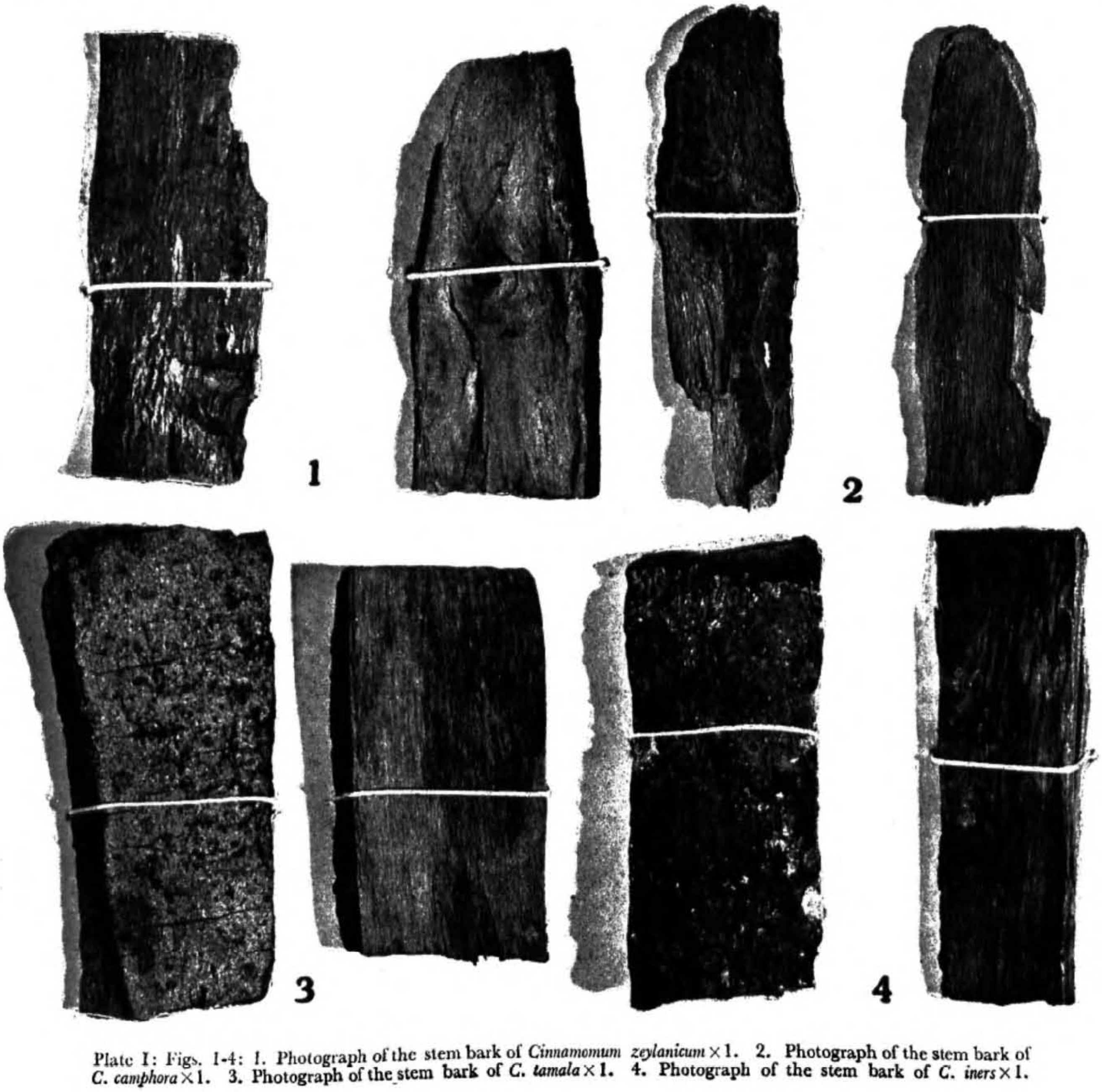


Plate I: Figs. 1-4: 1. Photograph of the stem bark of *Cinnamomum zeylanicum* × 1. 2. Photograph of the stem bark of *C. camphora* × 1. 3. Photograph of the stem bark of *C. tamala* × 1. 4. Photograph of the stem bark of *C. iners* × 1.

cyclic region by starch sheath. The cortex consists of thin-walled parenchymatous cells which are tangentially elongated, 10-16 layered in thickness. The cortical parenchyma cells give positive test for tannin. Some of the cortical cells contain starch grains and others are filled with a brownish substance (Plate II, Figs. 1 & 2). The cortical parenchyma cells measure T=35μ-74μ-104μ, R=16μ-30μ-46μ and L=18μ-46μ-62μ. The secretory cells containing oil are intermingled with cortical parenchyma cells which are tangentially elongated (Plate II, Fig. 1). The secretory cells measure 19μ-35μ × 35μ-92μ in T.S. The pericycle consists of a pale continuous ring of stone cells, 3-4 celled wide which are elongated tangentially, thick-walled and pitted. The cavities of some of the stone cells are greatly reduced. The inner walls of most of the stone cells are thicker than the outer ones which give a characteristic appearance (Plate II, Figs. 1 & 2 and Text Fig. 1). The stone cells measure T=28μ-67μ-113μ, R=23μ-30μ-46μ and L=28μ-39μ-58μ. Pericyclic fibres occur at intervals and are lignified, elongated and tapering at both ends (Plate II, Figs. 1 & 2). The pericyclic fibres measure 300μ-650μ in length and 18μ-35μ in breadth. The inner part of the stone-cell ring is bounded by 6-10 layers of parenchymatous, thin-walled and tangentially elongated cells which are intermingled with secretory cells containing oil and larger cells containing mucilage. The phloem which is about fifty per cent of the total thickness of the bark consists of sieve tubes, phloem parenchyma, phloem fibres and medullary rays. The sieve tubes are arranged in tangential bands which are completely collapsed in the outer layer. The sieve plates are on the transverse walls. Phloem parenchyma consists of sub-rectangular or rounded cells which are tangentially elongated and filled with innumerable starch grains and small acicular crystals of calcium oxalate. The starch grains are simple as well as compound. The simple starch grains are ovoid, rounded or elliptical. The compound starch grains are 2-5 compound. The starch grains measure 4μ-26μ in diameter. The pholem parenchyma cells give positive test for tannin and measure T=18μ-37μ-53μ, R=14μ-25μ-39μ and L=23μ-46μ-74μ Associated with the phloem parenchyma cells are the phloem fibres which are elongated tangentially, lignified, thick-walled and with very narrow lumen. The phloem fibres are isolated or in small, often radially arranged groups of 3-4 and measure 250μ-750μ in length and 16μ-30μ in breadth. Secretory cells containing oil and large cells containing mucilage are also scattered throughout this region (Plate II, Figs. 1, 2 & 3). The medullary ray cells are usually 2-celled wide, thin-walled, radially arranged. The medullary ray cells are wide near the pericycle and narrow towards the periphery, filled with either acicular crystals of calcium oxalate or starch grains. The medullary ray cells measure T=14μ-25μ-41μ, R=18μ-28μ-46μ and L=18μ-37μ-58μ (Plate II, Figs. 1, 2 & 3).

Powder: Light brown or yellowish brown in colour, odour fragrant, taste warm, sweet, pungent and aromatic. The powder when examined under the microscope is characterised by the presence of cork cells polygonal in surface view, rectangular cortical cells with or without starch grains and small acicular crystals of calcium oxalate, mucilaginous cells and oval cells, stone cells either in small groups or isolated pericyclic and phloem fibres and medullary ray cells. Numerous small acicular crystals of calcium oxalate are found scattered (Plate II, Fig. 4 and Text Fig. 1).

Chemical constituents: The bark contains a volatile oil (0.8 to 1.4%) phlobatannin, mucilage, calcium oxalate and starch. The chief constituent of the oil is cinnamic aldehyde 60-75%, though phellandrene, pinene cymene, linalol, nonyl aldehyde, caryophyllene, eugenol benzaldehyde, methyl amyl ketone etc. also exists in small quantities. The British Pharmacopoeia limits the amount of aldehydes to 50-65% but a genuine oil may contain as much as 75% (1, 3, 5, 8, 10, 13).

Uses: The bark is used as spices and condiment and is used in medicine only to a limited extent. It is used as carminative, astringent, stimulant and stomachic. It possesses the property of checking nausea and vomiting. It is also used as an ingredient of many medicines prescribed for bowel complaints, and is used externally in neuralgia, toothache etc. It is also given as a stimulant with other medicines in advanced stages of fever (1, 3, 5, 8, 10, 13).

Cinnamomum camphora Nees & Eberm. Hindi: Kapur, Bengali: Karpur, Karpuram; Eng.: Champhor, Cinnamon; Sans.: Karpura, is a large much-branched evergreen tree, attaining a height of 180 to 300 metre. It is a native of China, Japan, Formosa and commonly cultivated in India (1, 3, 5, 8, 10, 12, 13, 14).

Macroscopic characters: The stem bark is about 2-6 mm in thickness and when dried becomes curved.

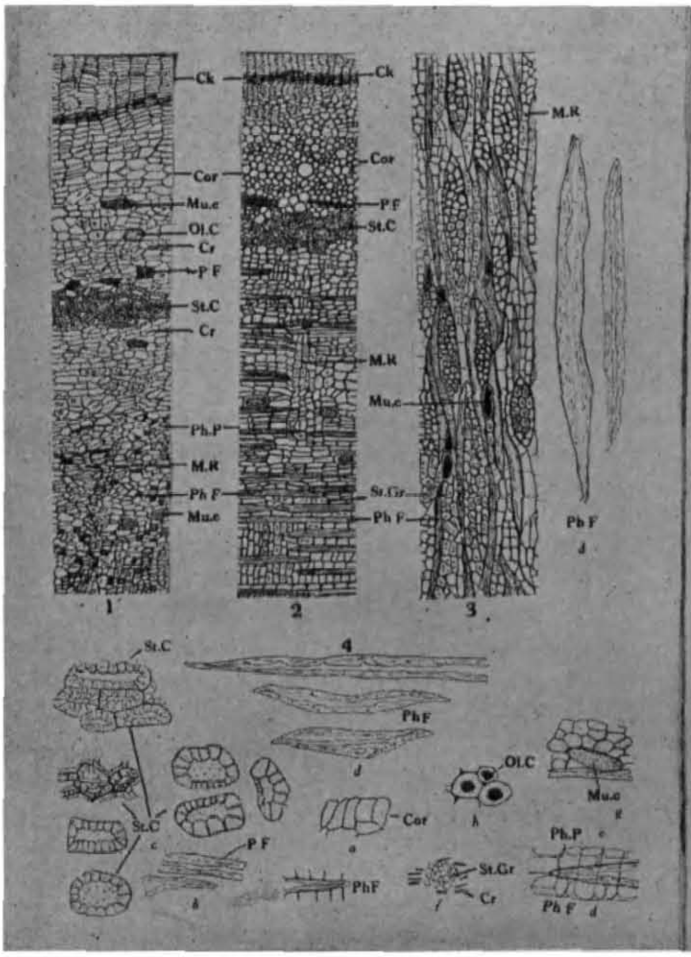


Plate II: Figs. 1-4: 1. Retouched photomicrograph of the transverse section of the stem bark of *C. zeylanicum* × 175. 2. Retouched photomicrograph of the radial longitudinal section × 175. 3. Retouched photomicrograph of the tangential longitudinal section × 175. 4. Camera lucida drawings of the different diagnostic elements as found in the powdered bark × 100.
(*a*) Group of cortical cells; (*b*) Pericyclic fibres; (*c*) Stone cells; (*d*) Phloem fibres; (*e*) Phloem parenchyma cells; (*f*) Crystals; (*g*) Mucilaginous cells; (*h*) Oil cells.

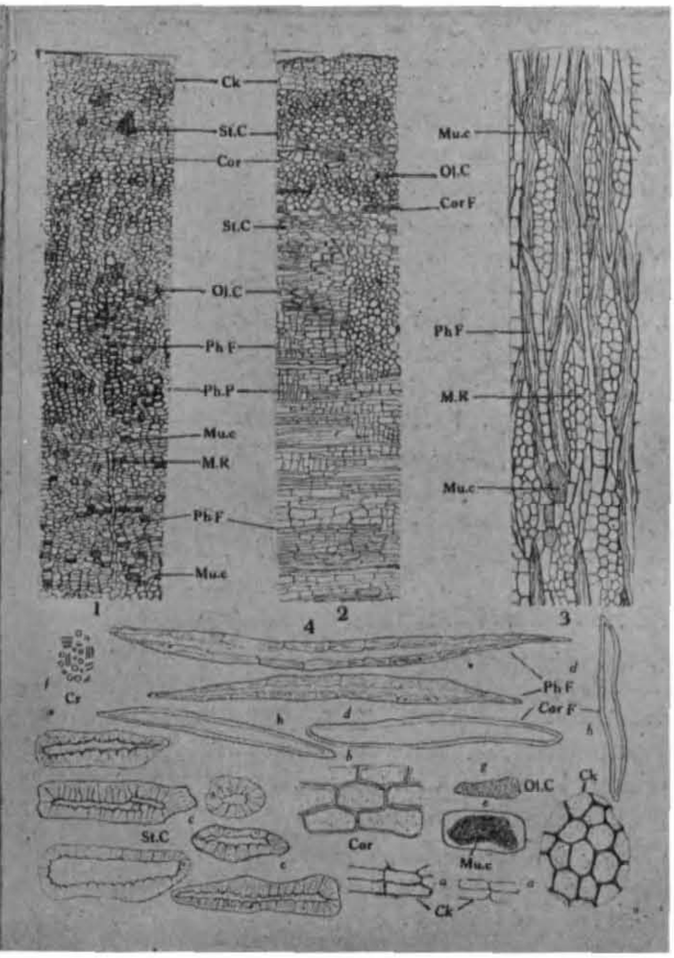


Plate III: Figs. 1-4: 1. Retouched photomicrograph of the transverse section of the stem bark of *C. camphora* × 175. 2. Retouched photomicrograph of the radial longitudinal section × 175. 3. Retouched photomicrograph of the tangential longitudinal section × 175. 4. Camera lucida drawings of the different diagnostic elements as found in the powdered bark × 100.
(*a*) Group of cork cells; (*b*) Group of cortical parenchyma cells; (*c*) Stone cells; (*d*) Phloem fibres; (*e*) Mucilaginous cells; (*f*) Crystals; (*g*) Oil cells; (*h*) Cortical fibres.

Ck = Cork; Cor = Cortical parenchyma cells; Cor. F = Cortical fibres; Cr = Crystals; M.R. = Medullary ray cells; Mu.C = Mucilaginous cells; Ol. C = Oil cells; Ph. F = Phloem fibres; Ph. P = Phloem parenchyma cells; St. C = Stone cells; H. St. C = Half stone cells; St. Gr = Starch grains.

The outer surface of the bark is greyish to greyish-brown in colour with greenish patches of mosses. The outer surface is uneven with raised scars and longitudinal fissures. The outermost corky layer when dried becomes exfoliated. The inner surface is brown in colour, smooth with fine longitudinal striations. Fracture brittle (Plate I, Fig. 2).

Microscopic characters: The phellem or cork consists of thin-walled tangentially elongated cells which fall off and are completely absent in the commercial samples. The cells are slightly suberized and 5-20 layers thick and measure $T=21\mu$-35μ-55μ, $R=12\mu$-15μ-18μ and $L=9\mu$-16μ-23μ (Plate III, Figs. 1 & 2). The phellogen layer is not distinct. The phelloderm or secondary cortex which occupies about thirty per cent of the total thickness of the bark consists of thin-walled parenchymatous cells, the cortex. The cortical cells are usually polygonal or rectangular in shape and contain starch grains which are distributed sparingly. The starch grains are mostly simple but a few compound grains are also present. The compound starch grains are generally 2-compound. The starch grains measure 4-15μ in diameter (Text Fig. No. 2). In the cortical region oil cells and mucilaginous cavities are also distributed (Plate III, Figs. 1, 2 & 3) Acicular crystals of calcium oxalate are present in some of the cortical parenchyma cells (Plate III, Figs. 1 & 2). The cells give positive test for tannin and measure T= 14μ-55μ-30μ, R=12μ-23μ-46μ and L=16μ-25μ-46μ. Stone cells either isolated or in groups associated with fibres are distributed in the cortical region. The stone cells are generally thick-walled with their walls striated (Plate III, Figs. 1 & 2). The stone cells measure T=23μ-28μ-32μ, R=12μ-16μ-21 μ and L=16μ-23μ-35μ, The secretory cells containing oil measure 28μ-46μ×23μ-46μ in T, S. and mucilaginous cells measure 39μ-58μ×23μ-35μ in T. S. The fibres are generally long with pointed ends (Plate III, Figs. 1 & 2), The fibres measure 300μ-800μ in length and 18μ-46μ in breadth. The phloem which occupies about seventy per cent of the total thickness of the bark consists of sieve tubes, phloem parenchyma, phloem fibres, secretory cells containing oil, mucilaginous cells and cavities and. medullary ray cells (Plate III, Figs. 1 & 2). The phloem parenchyma cells are thin-walled, polygonal or rectangular in shape and contain numerous oval or round starch grains which measure 4μ-15μ in diameter and acicular crystals of calcium oxalate. The phloem parenchyma cells measure T=14μ-30μ-53μ, R= 12μ-30μ. 46 μ and L=14μ-30μ-46μ. The secretory cells containing oil and mucilaginous cavities are similar to those found in the cortical region (Plate III, Figs. 1, 2 & 3). The phloem fibres are thick-walled, broadest in the middle and tapering at both ends. The fibres are lignified, with narrow lumen and with their walls straited (Plate III, Figs. 1, 2 & 3). The phloem fibres measure 250μ-700μ in length and 16μ-35μ in breadth. The medullary ray cells are thin-walled, radially elongated and generally 1-3 celled wide which separate phloem cells in groups (Plate III, Figs. 1, 2 & 3). These cells measure T=16μ-23μ-35μ, R=21μ-46μ-63μ and L=25μ-32μ-46μ.

Powder: Greyish to light brownish in colour with camphoraceous odour. Taste aromatic and camphoraceous. The powder when examined under the microscope is characterised by the presence of stone cells which are found scattered; cortical and phloem fibres either isolated or in groups, oil cells and mucilaginous cells, small groups of cortical cells and acicular crystals of calcium oxalate (Plate III, Fig. 4 and Text Fig. 2).

Chemical constituents: Cinnamomum camphora comprises many forms, some of them morphologically not differentiated but physiologically distinct. A few contain camphor while others produce only an aromatic oil (1, 3, 5, 10, 12, 13, 14).

Uses: The bark is used as sedative antispasmodic, diaphoretic and anthelmintic. It is also used in diarrhoea from cold. The camphor is employed externally in the form of spirit or liniment as a rubefacient; internally as a mild antiseptic and carminative and hypodermically in the form of a sterile solution in oil, as a cardiac stimulant (1, 3, 5, 10, 12, 13, 14).

Cinnamomum tamala Fr. Nees Beng.: Tejpat; Eng.: Cassia, Cinnamon; Hindi: Barahmi, Dalchini; Sans.: Tejpatra, is a moderate sized evergreen tree 1.4 meter girth and 7.5 meter high; distributed in tropical and sub-tropical Himalayas, 3000-7800 ft., Sylhet and Khasia Hills, 3000-4000 ft. The bark is dark brown or blackish slightly rough (1, 3, 8, 10, 13).

Macroscopic characters: The bark is 3-5 mm thick. The commercial samples are 8-12 cm or sometimes 20-25 cm in length and 3-5 cm wide. The bark when dried is slightly curved and sometimes in single quill. The outer surface is greyish brown in colour, rough and somewhat granular, occasionally with presence of transverse marks or undulation and with lenticels. The inner surface is smooth, light brown in colour. Fracture splintery (Plate I, Fig. 3).

Microscopic characters: In transverse sections the phellem consists of 10-20 layers of two kinds of tangentially elongated cork cells occurring in layers alternating with each other. One type consists of thin walled suberized cells and the other is followed by 2-3 layers of tangentially elongated sclerosed cork cells, the internal walls of which are lignified (Plate IV, Figs. 1 & 2). The cork cells measure T=23μ-44μ-62μ, R=14μ-23μ-32μ and L=9μ-21μ-32μ. The phellogen layer is more or less distinct due to the presence of a brownish content. The phelloderm or secondary cortex which occupy about one third of the total thickness of the bark consists of thin-walled cortical parenchymatous cells, stone cells, secretory cells containing oil, mucilage and tannin. The cortrial parenchymatous calls are thin-walled, generally 16-20 layer thick, oval or polygonal most of which are tangentially elongated. The cells contain starch grains which are mostly simple, round or some bi-compound ones. Besides starch grains the cells contain acicular crystals of calcium oxalate (Plate IV, Figs. 1 & 2). The starch grains measure 4-$27\,\mu$ in diameter. The cortical cells give positive test for tannin and measure $T = 37\mu$-67μ-92μ, $R = 14\mu$-28μ-41μ and $L = 14\mu$-32μ-46μ. Thick-walled stone cells occur in groups in the outer region of the cortex. Two types of stone cells are generally found in this bark. The ordinary stone cells and half stone cells (Plate IV, Figs. 1 & 2). The stone cells measure $T = 37\mu$-71μ-117μ, $R = 21\mu$-46μ-64μ and $L = 28\mu$-39μ-51μ. The secretory cells containing oil, mucilage and tannin are also found distributed (Plate IV, Figs. 1 & 2). The secretory cells measure 69μ. $115\mu \times 28\mu$-42μ in T.S. The cortical fibres are generally long broader in the middle and tapering at both ends with large lumen. The outer walls of these

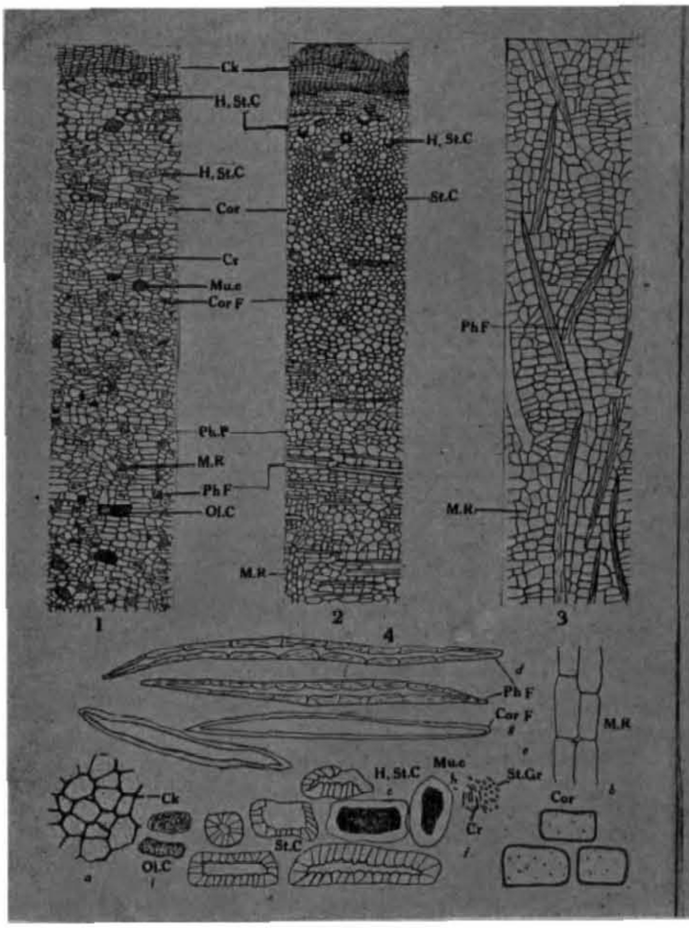


Plate IV: Figs. 1-4: 1. Retouched photomicrograph of the transverse section of the stem bark of *C. tamala* × 175. 2. Retouched photomicrograph of the radial longitudinal section × 175. 3. Retouched photomicrograph of the tangential longitudinal section × 175. 4. Camera lucida drawings of the different diagnostic elements as found in the powdered bark x 100.
(*a*) Group of cork cells; (*b*) Group of cortical parenchyma cells; (*c*) Stone cells; (*d*) Phloem fibres; (*e*) Medullary ray cells: (*f*) Crystals; (*g*) Cortical fibres; (*h*) Mucilaginous cells; (*i*) Oil cells.

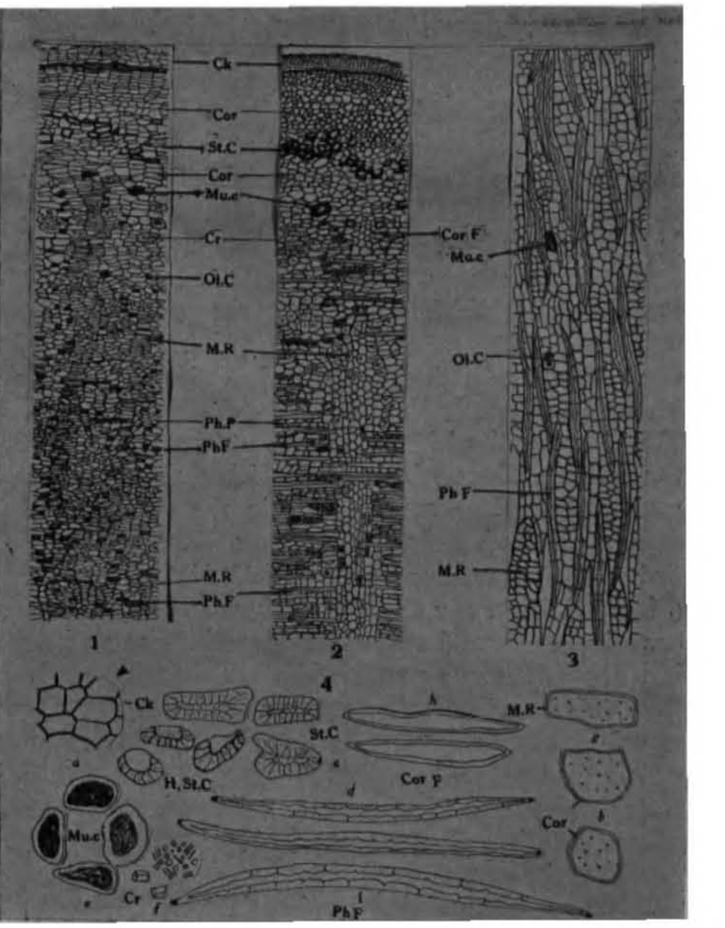


Plate V: Figs. 1-4: 1. Retouched photomicrograph of the transverse section of the stem bark of *C. iners* × 175. 2. Retouched photomicrograph of the radial longitudinal section × 175. 3. Retouched photomicrograph of the tangential longitudinal section × 175. 4. Camera lucida drawings of the different diagnostic elements as found in the powdered bark × 100.
(*a*) Group of cork cells; (*b*) Group of cortical parenchyma cells; (*c*) Stone cells; (*d*) Phloem fibres; (*e*) Mucilaginous cells; (*f*) Crystals; (*g*) Medullary ray cells; (*h*) Cortical fibres.

Ck = Cork; Cor = Cortical parenchyma cells; Cor. F = Cortical fibres; Cr = Crystals; M.R. = Medullary ray cells; Mu. C = Mucilaginous cells; Ol. C = Oil cells; Ph. F = Phloem fibres; Ph. P = Phloem parenchyma cells; St. C = Stone cells; H. St. C = Half stone cells; St Gr. = Starch grains.

fibres are slightly wavy (Plate IV, Figs. 1 & 2). The fibres measure 400μ-800μ in length and 23μ-46μ in breadth. The phloem which occupies about seventy per cent of the total thickness of the bark consists of sieve tubes, phloem parenchyma, phloem fibres and medullary ray cells, secretory cells containing oil and mucilage. The phloem parenchyma cells are generally polygonal in shape and are elongated tangentially. The cells are thin-walled and some of them are filled with starch grains while others are filled with acicular crystals of calcium oxalate. (Plate IV, Figs. 1 & 2). The phloem parenchyma cells measure T=23μ-46μ-62μ, R=14μ-28μ-46μ and L=18μ-23μ-39μ Large secretory cells containing mucilage and smaller secretory cells containing oil are distributed in the lower region of the secondary pholem either singly or in groups. Secretory cells containing oil are somewhat thick-walled and are either oval, polygonal or rectangular in shape (Plate IV, Figs, 1 & 2). These cells measure 28μ-58μ × 18μ-35μ in T.S. The mucilaginous cells measure 46μ-60μ × 35μ-50μ in T.S Associated with phloem parenchyma cells are the phloem fibres which occur either singly or in groups. The fibres are broadest in the middle and tapering at both ends. The phloem fibres are lignified with narrow lumen and with distinct stariations (Plate IV, Figs. 1, 2 & 3). The fibres measure 280μ-900μ in length and 21μ-35μ in breadth. The medullary ray cells are 1-3 cells wide, radially elongated, thin-walled and contain numerous acicular crystals of calcium oxalate (Plate IV, Figs. 1, 2 & 3). These cells measure T=14μ-20μ-28μ, R=23μ-39μ-58μ and L=25μ-46μ-81μ. Mucilaginous cells and secretory cells containing oil are same in size and shape as found in the cortex.

Powder : Dark brown to chocolate brown in colour, odour fragrant, taste aromatic and mucilaginous. The powder when examined under the microscope is characterised by the presence of cork cells which are polygonal in surface view; cortical cells, secretory cells containing oil and medullary ray cells with or without acicular crystals of calcium oxalate, cortical and phloem fibres, normal as well as half stone cells, numerous acicular crystals of calcium oxalate and starch grains (Plate IV, Fig. 4 and Text Fig. 3).

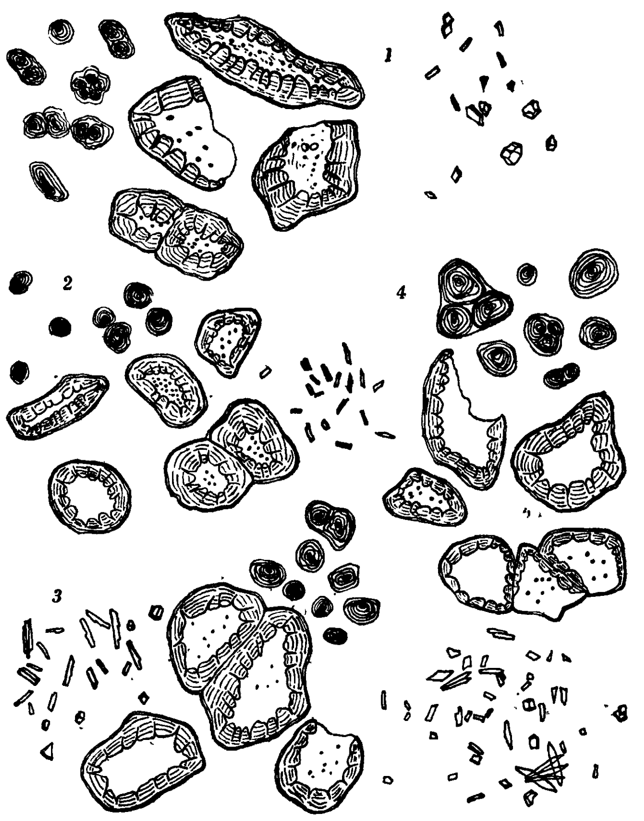
Chemical constituents : The outer bark yields on distillation an aromatic oil which is pale yellow in colour, 70-80% of Cinnamic aldehyde which is the chief constituent of *Cassia* oil (1, 3, 8, 10, 13).

Uses : The crude drug consists of stem bark which is carminative and is used in gonorrhoea (1, 3, 8, 10, 13).

Cinnamomum iners Reinw. Hindi: Darchini, Janglidarchini ; Sans.: Tejpatra ; Eng.: Cassia cinnamon is a large tree of Southern Tenasserim, Malay Peninsula, Sumatra, Java. Tropical and subtropical Himalayas, U.P., Bangla Desh, Khasia and Jaintia Hills and Burma. It is also reported to occur in the evergreen forest of Western ghats from Mysore and Coorg to the Anamalais and Travancore, Karnatic and Shevroy and Kollimalai hills (W.I.). The plant is a tree about 12 m tall, with short thick stem and large bushy top (1, 3, 8, 10 13).

Macroscopic characters : The commercial samples which are sold in the market are in pieces of 10-15 cm long and about 2-3 cm wide. Thickness of the bark varies from 2-6 mm or up to 1 cm sometimes. The bark when dried is curved and the curvature is in simple quills. The outer surface of the bark is light brown with greyish, white or yellowish green patches of lichens. The outer surface is rough with slightly elevated rounded or oblong lenticels and with transverse and longitudinal fissures on one side. Inner surface reddish brown, slightly rough or granular. Fracture tough, fractured surface uneven and slightly splintery in the inner region (Plate I, Fig. 4).

Microscopic characters : The phellem or cork consists of 10-15 layers of tangentially elongated slightly suberized cells all of which contains a reddish brown substance. The outer layer of the cork cells are generally thin-walled and the inner ones possess thick, pitted and colourless walls (Plate V, Figs. 1 & 2). The cork cells measure T=28μ-37μ-55μ, R=12μ-18μ-23μ and L=12μ-18μ-27μ. The phellogen and pholloderm layers are somewhat distinct in this bark. The phelloderm or secondary cortex consists of several layers of polygonal or tangentially elongated cells which contain acicular crystals and a few solitary prismatic crystals of calcium oxalate. Innumerable starch grains are also found in the cortical cells. The starch grains are either simple, round and pear-shaped 2-3 compound. The starch grains are 4-17μ in diameter. Few secretory cells containing essential oils and mucilaginous cavities are also distributed in the cortical region (Plate V, Figs. 1 & 2). Some of the cortical cells give positive test for lignin while most of the cells contain tannin. The cortical cells measure T=25μ-51μ-80μ, R=16μ-30μ-46μ and L=19μ-28μ-39μ. The mucilaginous cells measure 32μ-$81\mu \times 30\mu$-46μ in T.S. Large number of stone cells are present although they do not form a continuous ring. The stone cells vary in size and shape. They are either rounded or polygonal or tangentially elongated. Their walls are also pitted. Besides normal stone cells half stone cells are also found distributed (Plate V, Figs. 1 & 2). The stone cells measure T=37μ-55μ-81μ, R=14μ-32μ-46μ and L=25μ-35μ-44μ. Few secretory cells containing either mucilage or essential oils are found distributed in the pericycle. The cortical fibres are generally with pointed ends and large lumen and measure 300μ-550μ in length and 16μ-30μ in breadth. The phloem which is about fifty per cent of the total thickness of the bark consists of sieve tubes, companion cells, pholem parenchyma, phloem fibres and medullary ray cells, oil cells and mucilaginous cavities. The phloem parenchyma cells are thin-walled and either round or rectangular (Plate V, Figs. 1 & 2). Innumerable starch grains and acicular as well as prismatic crystals of calcium oxalate are found in these cells and also contain tannin. The phloem parenchyma cells measure T=18μ-37μ-58μ, R=18μ-25μ-43μ and L=16μ-28μ-46μ. Phloem fibres are very prominent and are distributed throughout this region, either isolated or in radial or tangential groups with distinct striations and comparatively with narrow lumen. The phloem fibres measure 400μ-1 mm in length and 16μ-46μ in breadth. The secretory cells are somewhat smaller in size and fewer in number than *Cinnamomum zeylanicum*. The medullary rays are 2-4 celled wide radially elongated and filled with simple starch grains, acicular crystals of calcium oxalate and a brownish substance (Plate V, Figs. 1, 2 & 3). The medullary ray cells measure T=18μ-25μ-35μ, R=30μ-41μ-51μ and L=39μ-58μ-71μ.



Text Figs. 1-4: 1. Camera lucida drawings in details of the Stone cells, Starch grains and Crystals of calcium oxalate of the powdered bark of *C. zeylanicum* × 300. 2. Camera lucida drawings in details of the Stone cells, Starch grains and Crystals of calcium oxalate of the powdered bark of *C. camphora* × 300. 3. Camera lucida drawings in details of the Stone cells, Starch grains and Crystals of calcium oxalate of the powdered bark of *C. tamala* × 300. 4. Camera lucida drawings in details of the Stone cells, Starch grains and Crystals of calcium oxalate of the powdered bark of *C. iners* × 300.

Powder: Deep brown to chocolate brown in colour, taste astringent and slightly pungent odour aromatic. The powder when examined under the microscope is characterised by the presence of cork cells, rectangular cortical cells with or without starch grains and acicular and few prismatic crystals of calcium oxalate. Normal as well as half stone cells, mucilaginous cells, cortical and phloem fibres, small groups of medullary ray cells, numerous acicular crystals and few prismatic crystals of calcium oxalate are present (Plate V, Fig. 4 and Text Fig. 4).

Chemical constituents: The outer bark of the plant yields on distillation about 0.5% of an essential oil (similar to Cinnamon oil) which has a pale yellow colour. In Cinnamon oil, the associated materials, *e.g.* pinene, non-aldehyde etc. have a fragrant and delicate odour. The inner bark possesses in the fresh state a powerful cinnamonic odour and taste (1, 3, 5, 8, 10, 13).

Uses: The bark is carminative, antispasmodic, aromatic, stimulant, haemostatic, astringent, antiseptic, stomachic and germicide. The bark of young shoots is used as spice. The bark in infusion, decoction, or powder, or oil is prescribed in bowel complaints such as dyspepsia, flatulence, diarrhoea and vomiting. It is frequently employed as an adjunct to bitter tonics, purgatives, and vegetable and mineral astringents. As a stimulant of the uterine muscular fibre it is employed in menorrhagia and in tedious labour due to defective uterine contractions. Powdered cinnamon in 10 to 20 grains doses is a reputed remedy given in diarrhoea and dysentery. The crystalline cinnamic acid is antituberculor and is used as injection in phthisis. As a powerful stimulant, cinnamon is given in cramps of the stomach, enteralgia, toothache and paralysis of the tongue (1, 3, 5, 8, 10, 13).

TABLE SHOWING DIFFERENCES IN THE BARKS OF FOUR SPECIES OF *CINNAMOMUM*

	C. zeylanicum	*C. camphora*	*C. tamala*	*C. iners*
Macroscopic characters :				
(*a*) Thickness	1-5 mm sometimes upto 10 mm	2-6 mm	3-5 mm	2-6 mm sometimes upto 1 cm
(*b*) Colour	Externally brownish or dark-brown sometimes greenish-brown	Externally greyish to greyish-brown	Externally greyish-brown	Externally light brown with greyish white
	Inner surface brownish to creamy white	Inner surface brown	Inner surface light brown	Inner surface reddish brown
(*c*) Quills	Closely rolled categories of quills	Curved	Sometimes in single quills	Simple
(*d*) Fracture	Weak, brittle, splintery or uneven	Brittle	Splintery	Tough, slightly splintery in the inner region
(*e*) Odour	Fragrant and strong	Camphoraceous	Fragrant	Aromatic more or less like that of Sassafras.
(*f*) Taste	Warm, sweet, pungent and aromatic	Aromatic, Camphoraceous	Aromatic and mucilaginous	Astringent, slightly pungent and aromatic
Microscopic characters :				
(*a*) Phellem	5-10 layers of thin-walled tangentially flattened suberized cork cells	5-20 layers of tangentially elongated cells, slightly suberized	10-20 layers of two kinds of cork cells alternating each other which are either suberized or sclerosed	10-15 layers of slightly suberized and contain reddish-brown substance
(*b*) Phellogen	Not distinct	Not distinct	More or less distinct due to presence of a brownish content	Somewhat distinct
(*c*) Phelloderm	Not sharply defined from pericyclic region. 10-16 layers of tangentially elongated cells which contain either starch grains or filled with a brownish substance	Several layers of cells which contain either starch grains which are sparingly distributed or contain acicular crystals of calcium oxalate	16-20 layers of tangentially elongated cells which either contain starch grains or acicular crystals of calcium oxalate	Several layers of tangentially elongated cells which contain starch grains, acicular crystals and a few prismatic crystals of calcium oxalate
Secretory cells	Cells containing oil are intermingled with cortical parenchyma cells and some containing oil and large cells containing mucilage are scattered in the phloem region	Distributed in the cortical and phloem region which contain oil	Distributed in the cortical and phloem region. These cells contain oil, mucilage and tannin	Few cells containing essential oils and mucilage are distributed in the cortical and pericycle regions
Stone cells	Middle part of the bark contains tangentially elongated sometimes thick-walled sclerenchymatous stone cells with reduced cavities. Inner walls are thicker than outer.	Distributed in the cortical region either isolated or in groups associated with fibres, generally thick-walled with their walls striated	Distributed in the outer region of the cortex thick-walled.	Stone cells are separated by cortical parenchyma cells with pitted walls and slightly thickened at one side. A few are occasionally found in the best region
Half stone cells	Present	Absent	Present	Present

	C. zeylanicum	*C. camphora*	*C. tamala*	*C. iners*
Cortical fibres	Pericyclic fibres lignified elongated and tapering at both ends	—	Same as *C. zeylanicum*	With pointed ends and large lumen
Phloem parenchyma	Tangentially elongated, rectangular or rounded, contain minute starch grains, small calcium oxalate crystals in raphides or clinorhombic forms	Polygonal or rectangular contain starch grains and crystals of calcium oxalate in raphides	Tangentially elongated, polygonal, contain starch grains and crystals of calcium oxalate in raphides	Thin-walled either round or rectangular, contain starch grains and crystals of calcium oxalate in raphides or prismatic forms
Phloem fibres	Lignified, thick-walled with very narrow lumen, isolated or in small radially arranged groups of 3-4; 250-750 μ long and 16-30 μ broad	Lignified, thick walled with narrow lumen and with their walls striated; 250-700 μ long and 16-35 μ broad	Lignified with narrow lumen and with distinct striations; 280 900 μ long and 21-35 μ broad	Distributed throughout the phloem region, either isolated or in radial or tangential groups with distinct striations and comparatively narrow lumen. 400μ-1 mm long and 16-46 μ broad
Oil secretion cells	Secretory cells containing oil and large cells containing mucilage are scattered throughout	Comparatively smaller secretory cells containing oil and mucilaginous cavities are found	Large secretory cells containing mucilage and smaller ones containing oil are distributed in the lower region of the secondary phloem either single or in groups	Secretory cells are somewhat smaller and fewer in number than *C. zeylanicum*
Medullary ray cells	2-celled wide, radially arranged, wider near the pericycle and narrow towards the periphery, filled with starch grains and raphides of calcium oxalate	1-3 celled wide radially elongated	1-3 celled wide, radially elongated, contain numerous raphides of calcium oxalate	2-4 celled wide, radially elongated, filled with starch grains, raphides of calcium oxalate and a brownish substance
Powder	Light brown or yellowish brown in colour, odour fragrant, taste warm, sweet, pungent and aromatic. Characterised by the presence of cortical cells with starch grains and small acicular crystals of calcium oxalate, mucilaginous cells, stone cells, pericyclic and phloem fibres, acicular and a few prismatic crystals of calcium oxalate	Greyish to light brownish with camphoraceous odour. Taste aromatic and camphoraceous. Characterised by the presence of stone cells, cortical and phloem fibres, oil and mucilaginous cells, cortical cells and acicular crystals of calcium oxalate	Dark brown to chocolate brown, odour fragrant, taste aromatic and mucilaginous. Characterised by the presence of cork cells, cortical cells, secretory cells containing oil, medullary ray cells with or without acicular crystals of calcium oxalate, and a few prismatic crystals of calcium oxalate	Deep brown to chocolate brown, odour aromatic, taste astringent and slightly pungent. Characterised by the presence of cork cells, cortical cells with or without starch grains and acicular and few prismatic crystals of calcium oxalate. Normal as well as half stone cells, mucilaginous cells, cortical and phloem fibres

KEY TO THE INDENTIFICATION OF BARKS AND THEIR POWDERS FROM ANATOMICAL CHARACTERS OF FOUR SPECIES OF *CINNAMOMUM*

Crystals of calcium oxalate acicular

Stone cells present occur in the cortical region
  Half stone cells absent
    Starch grains mostly simple but few compound (2-compound) diameter 4-15μ ... *C. camphora*

Crystals of calcium oxalate acicular and a few prismatic

Stone cells abundant forms a continuous ring in the pericycle
  Half stone cells present
    Starch grains simple as well as compound (2-5 compound) diameter 4-36μ ... *C. zeylanicum*

Stone cells occur in groups in the outer region of the cortex
  Half stone cells present
    Starch grains simple as well as compound (2-compound) diameter 4-27μ *C. tamala*

Stone cells abundant but do not form a continuous ring
  Half stone cells present
    Starch grains simple as well as compound (2-3 compound) diameter 4-17μ ... *C. iners*

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